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Teacher orchestration of classroom interaction in science: Exploring dialogic and authoritative passages in whole-class discussions

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Abstract

Whereas science is fundamentally a result of a dialogic debate, the authoritative approach has been conceived of as a fundamental part of school science. Dialogic interactions encompass the mutual appreciation of different ideas manifested in teacher supportiveness toward students and, in authoritative interactions, the focus is more on the science's or teacher's point of view. Whereas dialogic and authoritative interactions have been viewed as oppositional in recent educational research, authoritative interactions could well be the seed for and give strength and meaning to dialogic interactions, and thus, to the overall dialogue. The focus in this study is on the interplay between authoritative and dialogic interactions rather than on the rivalry between them. In other words, we present how both dialogic and authoritative interactions can be essential for teacher orchestration of whole-class discussions. This is achieved through a temporal consideration of the interactions and an in-depth analysis of selected episodes of a case science teacher. Interpretations are complemented with teacher reflections to shed light on the on-the-fly decisions made by the teacher when orchestrating dialogue. Implications for educational research and teacher education are discussed.

Key words: Classroom interaction in science; Communicative approaches; Teacher orchestration

Introduction

> Both dialogicity and authoritativeness contain the seed of their opposite pole in the dimension, and in this way we see the dimension as tensioned and dialectic, rather than as being an exclusive dichotomy. Following these ideas, we see teaching for meaningful learning in terms of a progressive shifting between authoritative and dialogic passages, with each giving rise to the other. (Scott, Mortimer, & Aguiar, 2006, p. 623)

The above quotation addresses the focus of this study: Balancing the dialogic and authoritative in-teacher orchestration of whole-class discussions. More than a decade later, there is still work

to be done to understand the critical points arising within authoritative and dialogic passages. Indeed, the thin line between authoritative and dialogic interactions is often disregarded due to the dichotomy; thereby, we may have missed the essential aspects when delving into the challenges that arise with dialogicity (Lehesvuori, Viiri, & Rasku-Puttonen, 2011; Lehesvuori, Ramnarain, & Viiri, 2018). Or, just as interestingly, we may have missed the situations in which dialogic interaction is made possible despite the prevailing authoritativeness. The exploration of how interactions shift from one form to another requires detailed attention being placed on the temporal and dynamic nature of classroom interactions (Littleton & Kerawalla, 2012; Ludvigsen, Rasmussen, Ingeborg, Moen, & Middleton, 2010; Lehesvuori, Viiri, Rasku-Puttonen, Moate, & Helaakoski, 2013; Nurkka, Viiri, Littleton, & Lehesvuori, 2014). The balance and shifts between dialogic and authoritative passages are challenging for educational research, but most of all, we find that this is also challenging yet possible for a teacher when orchestrating whole-class discussions. We consider that more light can be shed on these issues through further developing the concepts of dialogic and authoritative passages.

The emphasis on classroom interaction and, in particular, on verbal communication, originates from the sociocultural approach (Vygotsky, 1978). In the context of this study, this covers the benefits of verbal communication in the development of a joint understanding as well as the higher order thinking skills of individuals triggered through verbal communication. The sociocultural perspective provides a framework for examining the link between language and learning and has become an increasingly popular approach among scholars in the field of education (Littleton & Howe, 2009; Mercer, 2004; Reveles, Kelly & Durán 2007). When it comes to dialogicity, the ideas of Bakhtin (1986) foreground the need for different voices and ideas having their place. Dialogicity needs to be emphasized due to its ongoing infrequent presence in the science classroom (Mercer, Dawes, & Staarman, 2009; Lehesvuori et al., 2013). However, herein, we equally bring forth the role of the authoritative approach in the meaningful learning of science (Lehesvuori et al., 2013; Scott & Ametller, 2007). To foreground the issue in terms of learning, Furtak and Shavelson (2009) have presented preliminary evidence that instead of consisting of a single dominant communicative approach, a mix of communicative approaches would better facilitate student learning. Accordingly, recent studies have shown some signs that instruction including dialogic interaction correlates with students' academic performance (Muhonen, Pakarinen, Poikkeus, Lerkkanen, & Rasku-Puttonen, 2018).

Despite the equal role of different communicative approaches having been discussed (Mortimer & Scott, 2003; Scott et al., 2006), there are still limited studies bringing explicitness to this issue. Furthermore, there are even fewer studies applying this explicitness to theory development on how authoritative and dialogic passages build on each other. Delving into the challenge of orchestrating meaningful classroom discussion could provide educational researchers and educators with more information about why dialogicity is so infrequent in science classrooms, despite it being increasingly adapted to curricula through student-centeredness (Finnish National Board of Education [FNBE], 2016; Lehesvuori, Chan, Ramnarain, & Viiri, 2017) and teacher education through interventions (Sedova, Sedlacek, & Svaricek, 2016; Lehesvuori, Hähkiöniemi, Jokiranta, Nieminen, Hiltunen, & Viiri, 2017). There is also recent work in terms of enhancing productive science discourse through emphasis being placed on the role of the teacher orchestrating whole-class discussions (Zaccarelli, Schindler, Borko, & Osborne, 2018).

There are some previous works on the challenges arising from balancing dialogic and authoritative forms of interaction (Lehesvuori, Viiri, & Rasku-Puttonen, 2011; O'Connor, Michaels, Chapin, & Harbaugh, 2017). Our focus here, however, is more on the possibilities when it comes to different approaches as a catalyst when compared to others. In particular, we delve into the situations where authoritative passages could support the subsequent dialogic interactions, or correspondingly, where dialogic passages bring the student's voice and elaborations back into the dialogue. These aims are addressed through a case-study approach by examining examples of a teacher-orchestrated whole-class discussion and teacher reflections on selected examples.

Theoretical background on classroom interaction

Dialogic and authoritative interactions

Before addressing the model where dialogic and authoritative approaches are seen as a more united part of the meaningful learning of science (Scott & Ametller, 2007), we open up the different nature of these approaches. What is characteristic of the *authoritative approach* (Mortimer & Scott, 2003) is the teacher maintaining ownership of the ideas. This is congruent with a dispersive teacher role (Chen, Hand, & Norton-Meier, 2017) where the teacher has the ownership of the activity. Thus, in the authoritative approach, there really is no space for

authentic dialogicity where ideas are considered mutually (Bakhtin, 1986); rather, students follow the idea of science framed by the teacher or other related authority such as textbooks (Teo, 2016). Although interactions could consist of interactive triadic initiation–response–feedback (IRF; Lemke, 1990; Sinclair & Coulthard, 1975) or initiation–response–evaluation (IRE; Mehan, 1979) patterns, questions in authoritative interactions are often closed questions (Chin, 2007), with a clear right or wrong answer expected from the students. Briefly, the teacher simply delivers information to the students in this role or expects students to stay on a pre-defined path.

In dialogic interactions and through the *dialogic approach*, the teacher solicits input from the students, sequences ideas, asks open questions, draws out ideas, and asks students to build on or respond to each other's ideas (Mortimer & Scott, 2003). The teacher is not trying to push his/her own ideas into the conversation, but instead through back-and-forth exchanges creates a space including many different perspectives. Often, the teacher aims to elicit students' everyday views or lived experiences (Fleer, 2015). This resembles a derived interaction pattern within which the teacher is aiming to elicit and bring forth student thinking as a part of the formative assessment process (Furtak, Glasser, & Wolfe, 2016; Ruiz-Primo & Furtak, 2007). In this pattern, the follow-up move has been re-described as a teacher prompt (P), constituting a more chained kind of pattern of initiation–response–prompt–response–prompt (IRPRP; Scott et al., 2006). Specific for dialogic interaction, the teacher can comment on ideas to draw out more thinking but is non-evaluative and non-judgmental of student ideas at this point. The teacher could relinquish the control of the discussion to the student. In this study we demonstrate how this is done under teacher control.

As outlined above, dialogicity is often weighted against the presence of different views and, thus content of the discussion. But, there's still place for extended interpretation:

> "By way of contrast, authoritative discourse does not allow the bringing together and exploration of ideas. Here the teacher focuses attention on the school science point of view. If <u>ideas or questions</u>, which do not contribute to the development of the school science story, are raised by students, they <u>are likely to be reshaped or ignored by the teacher</u>." (Scott, Mortimer, & Aguiar, 2006, p.2)

Communicative approaches are often considered alongside teaching purposes of the teacher and presence of different views (Mortimer & Scott, 2003). We, however, expand to weight also how teacher reactions towards student endeavors (not only ideas) in the moment shape the surrounding communicational nature. Rephrasing the underlined (by author) sentences, we argue that if teacher is reshaping or neglecting student ideas or questions, an authoritative approach is taking place (at least momentarily). In other words, if teacher ignores student idea(s) contributing to either science or everyday/students' views, the near temporal surrounding are stigmatized with authoritativeness nevertheless the dialogicity would still be prevailing and resonating with the overall teaching purpose. As from Bakhtinian point of view dialogicity is about mutual consideration of different ideas, we think that in fundamentally asymmetric classrooms it is also, and as importantly, about how openly we welcome others to discussion.

As discussed elsewhere (Lehesvuori, Ramnarain, & Viiri, 2018), communicative approaches are build of indicators influencing their temporal surroundings and finally constituting as whole episodes with a dominating approach. In this paper, these indicators are linked to authoritative and dialogic passages that in temporal scale give meaning to or path students back to the opposing and prevailing communicative approach.

Teacher as an orchestrator of classroom interaction

Teacher orchestration of whole-class discussions is a reasonably well-researched topic (Mercer, Hennessy, & Warwick, 2010), yet it lacks coherent conceptualization. As descriptive as it is to assimilate orchestration into music and how the teacher creates the rhythm of the talk and the tempo (Alexander, 2001), the ways in which orchestration explicitly takes place and how this can be illustrated are still rarely addressed (Lehesvuori et al., 2013). One description for the teacher's orchestration of a dialogue is the teacher harnessing and interweaving students' contributions and making shifts between what is foregrounded and what is backgrounded in pursuit of overall pedagogical goals (Littleton & Kerawalla, 2012). Teacher orchestration is often assimilated into how the teacher organizes his/her classroom activities within which learning can most effectively take place (Pianta, Hamre, & Mintz, 2010). More recently, the focus has been on the teacher orchestrating activities in digitalized learning environments (Hämäläinen, Kiili, & Smith, 2017).

Having said this, and getting closer to the focus of this study, teacher orchestration can also be weighed against how the teacher supports students to engage in collaborative dialogue (Webb, 2009; Bansal, 2018). In its simplest form, orchestration has been understood as the teacher merely moderating the dialogue (Chen et al., 2017). This means that the teacher gives turns to students to share their ideas and acknowledges them (cf. "idea sharing" in Berland & Hammer, 2012, p. 75), yet not really evaluating, elaborating, or pushing students further in their thinking. In Bansal's (2018) study, the orchestration of dialogic interactions focuses closely on the variations in the teacher's follow-up turns. Coming back to meaningful learning, the emerging ideas should be weighted in meaning-making processes including a more thorough consideration of both authoritative and dialogic communicative approaches in the end (Scott & Ametller, 2017). There is some evidence that pre-structured forms and the orchestration of dialogue can even stimulate students' authentic reasoning (Evans & Dawson, 2017). Yet, we explicitly examine what teacher orchestration in whole-class discussions means in terms of how the teacher balances different communicative approaches on the fly when orchestrating the dialogue. At the same time, a whole-class discussion is found to be an effective way to access student ideas (Lehesvuori et al., 2013) and develop higher order reasoning skills (Evans & Dawson, 2017), and the communication spectrum in whole-class discussions has been found to be narrow (Myhill, 2006), especially when it comes to science (Lehesvuori et al., 2013).

The orchestration has both *in situ* and temporal aspects (Lehesvuori et al., 2013). That is, the teacher implements different communicative approaches in different parts (episodes) of the lesson. Likewise, the teacher orchestrates the discussion within an episode to maintain a specific form of interaction. One example of a temporal communicational structure could be a dialogic inquiry-based learning sequence that is split into three sections: introducing the problem (dialogic approach); inquiry (peer discussion); and the conclusion (authoritative approach). This structure is more thoroughly discussed elsewhere (Lehesvuori, Ratinen, Kulhomäki, Lappi, & Viiri, 2011). The point here is that we are considering temporality. To initiate an introductory dialogic interaction in the first place instead requires specific verbal actions firstly to activate students to share their ideas and secondly to maintain the dialogic space (Lehesvuori, Ramnarain, & Viiri, 2018). These actions can differ from the prevailing communicative surroundings. We see this all being connected to teacher orchestration of whole-class discussions featuring an interplay between and balancing of authoritative and dialogic interactions and manifesting as passages of such.

There is an underlying tension between the ground rules for participation and more student-driven dialogic interaction (Kumpulainen & Rajala, 2017). The level of orchestration could depend on how these ground rules have been presented and practiced. In the "Thinking Together" program introduced by Mercer (2000), rules for enhancing exploratory talk are explicitly practiced and found to work in terms of activating more students to take part in meaningful interactions (Mercer et al., 2010). Within the context of this study, we have a congruent aim when it comes to bringing argumentation into classroom interactions in science and mathematics (Lehesvuori et al., 2017).

Research questions

The main research questions explored in this study are as follows:

- How does the teacher balance the dialogic and authoritative approaches while orchestrating whole-class discussions?
- How does the teacher reflect on balancing the dialogic and authoritative approaches?

To explore teacher orchestration and balancing, we examine the following examples and instances of classroom interaction:

1. *An authoritative passage* where the teacher sets the ground rules for dialogic interactions;
2. A dialogic interaction where the teacher withdraws from taking control and *maintains an open dialogic space;* and
3. *A dialogic passage* where the teacher opens the floor up momentarily for student–student interaction.

The results provide further information on explicit actions that teachers use to orchestrate the whole-class discussion through communicative approaches. Furthermore, through teacher reflections, we have an opportunity to shed light on the struggle that the teacher faces when balancing the authoritative and dialogic approaches. In this study, the communicative approach is based on Mortimer and Scott's (2003) descriptions and is something that manifests as an interaction of such. In other words, when stressing the communicative approach instead of interaction, the focus is more on the teacher's actions rather than on the resulting interactions.

Method

Context

This study is a part of a larger project addressing argumentation in science and mathematics. The project included a two-year (semesters from 2016–2018) intervention program for six teachers. Briefly, the aim was to enrich teacher communication in science and mathematics classrooms. The cornerstone for the designed professional development (PD) program was to create the space for teachers to repeat opportunities to plan and implement dialogicity and argumentation in their teaching, and to reflect upon it during the two-year program. Whereas researchers insert theoretical knowledge into the argumentation tasks, the teachers were expected to and were given opportunities to share their practical experiences and expertise. The PD program consisted of cycles structured by three phases (cf. Westerman, 1991):

1) *Pre-active:* A preliminary planning session in which a draft of the task enhancing dialogic argumentation is introduced by the researchers and modified based on teachers' remarks
2) *Interactive:* A video-recorded implementation of the task
3) *Post-active:* A reflective PD discussion on researcher chosen excerpts from the video-recorded lesson

In the PD training, explicit examples were provided through videos for reflection. Conceptualisations were then addressed and developed jointly in subsequent planning and reflective sessions.

The PD program included continuous discussions and co-operation between scholars and teachers, aiming toward increasingly dialogical and student-centered classroom discourse practices (Kiemer, Gröschner, Pehmer, & Seidel, 2015). In order to lay the ground for dialogic argumentation, the starting point was first to familiarize teachers with dialogic interaction before moving towards the content and structure of argumentation. Whereas the focus was more on dialogicity during first year, the role of argumentation was given more and more

weight during the program. Additional information of the intervention can be found in article discussing how teachers' adopted dialogicity in to their views (Lehesvuori et al., 2017).

The case teacher

The case teacher has more than 20 years of experience in teaching physics, chemistry and mathematics in Finnish secondary schools. The students in the case class are 7th graders (13 years old) and have just began their secondary level studies. One of the major difference between primary and secondary level studies is the greater enrollment of science subjects (i.e., physic and chemistry).

The selection of the case teacher was based on the initial on-the-fly observations and initial analysis of the video data and reflections. During 7th grade physics unit topics such as oscillation, wave motion, light, reflection, refraction and lenses are covered. The case lesson (45 min) was the first physics lesson of the intervention and the topic was about mirrors and reflection. Based on preliminary findings from the first quarter of the intervention, we are able to say that the case teacher was one of the six teachers who had also adapted the principles of dialogicity into his views (Lehesvuori et al., 2017). The data for this paper includes whole-class discussions (9 minutes in the end of the lesson) and PD-related discussions with the teacher. One of the main reasons for the selection of the case teacher was his solid orchestration of whole-class discussions: The instruction was structured, well-organized, and followed the same instructional pattern. At the same time, within his orchestration, the teacher seemed to balance the dialogic and authoritative approaches within and between episodes (to be examined further in the methods). We have provided contrasting case examples of dialogic and authoritative episodes elsewhere (Lehesvuori, Ramnarain, & Viiri, 2018), yet here the focus is on "somewhere between" the dialogic and authoritative approaches. It was this balancing of the dialogic and authoritative approaches, which was evident from the initial observations, video analysis, and the teacher's reflections, that raised the researchers' interest toward the further conceptualization of teacher orchestrations of whole-class discussions.

Data collection and analysis

Lessons were video recorded with one camera following the teacher. The teacher carried a portable microphone linked to the camera. The microphone was sufficient to capture the whole-

class discussions. If there were issues of inaudibility, student utterances were checked from cameras placed in every student group. The interviews were reflective discussions based on pre-selected video clips presenting features of dialogicity where two researchers and the case teacher were present for the session. Despite pre-selection and pre-structuring, the idea was to have as open-ended an approach to interviews/reflections as possible (Kvale, 1996; Yin, 1994).

As the selection of the case teacher is introduced above, the selection procedure and the analysis of the analytical units are covered below. Firstly, a typical lesson structure would include three phases:

1. *An introduction* and setting up the problem and instructions for group discussions;
2. *Group work and peer discussions* following the guidelines for the task (where the teacher has more of a scaffolding role when he collects ideas for the whole-class discussions); and
3. *Whole-class discussions* with a focus on student argumentation before closing the discussion down.

Because of the very structured orchestration (of activities), the selection of the episodes in the whole-class discussions was straightforward. The teacher typically shared turns with one student group at a time. Or, the teacher instigated a joint dialogue on one task at a time. Thus, changes in episodes are explicitly signaled by the teacher giving a turn to another student group or shifting to another task to be discussed. In our previous study (Lehesvuori et al., 2013), a change in the dominant communicative approach was considered as an indicator of a change in episode. In other words, brief communicative passages were not elaborated on or brought forth in the episode-based (meso-level) analysis. However, here the focus is on these passages and on the role that they played in the temporal communicative surroundings (i.e., within episodes).

The episodes of the whole-class discussions are presented in figure 1. The overall duration of the whole-class discussion phase was 10 minutes. The duration of the single episodes is not the focus here; instead, the dialogic and authoritative approaches are presented. Thus, some interpretations on the rhythm can be undertaken (cf. Lehesvuori et al, 2013; Nurkka et al., 2014), yet we are mainly interested in the shifts between the authoritative and dialogic approaches within an episode (marked in the figure with rising or falling arrows). As described,

an episode constitutes a group's turn to contribute to the discussion and could include interaction between groups. The communicational shifts within an episode can be understood as passages: Authoritative and dialogic passages are indicated in the second (authoritative) and seventh (dialogic) episodes with up/down/up arrows. While communicative approaches are examined in the theoretical background, a passage is described here as the teacher interrupting the dominant interaction with an opposite one within an episode:

- An authoritative passage often involves the teacher giving directions or asking directing questions, yet not closing down the dialogic interaction completely within an episode. I.e., an authoritative passage guides students back to dialogic discussion through more closed prompts.
- A dialogic passage could be the teacher opening the floor up for a brief exchange of ideas, or the teacher grasping a student's response or initiation (e.g., Wonderment question; Aguiar, Mortimer, & Scott, 2009), but the teacher does not give up his overall control of the direction. I.e., dialogic passage brings in different views, yet the space is not opened for extended dialogic discussion.

We understood a communicative passage as a path that gives more meaning to or paths students back to the prevailing communicative approach. For example, the dialogic approach could be strengthened in terms of conceptual learning when the teacher takes the students back onto topic by reinforcing or reviewing their elaborations. Contrastingly, the authoritative approach could be given more meaning in terms of joint meaning-making as the teacher quickly brings the student voice back to the dialogue. We have briefly introduced the term "dialogic moment" in another paper (Lehesvuori et al., 2013). Aligning with the term "passage," we aim to highlight the temporal nature of communication and how the dialogic and authoritative moments play a temporal role in passaging students in meaningful learning.

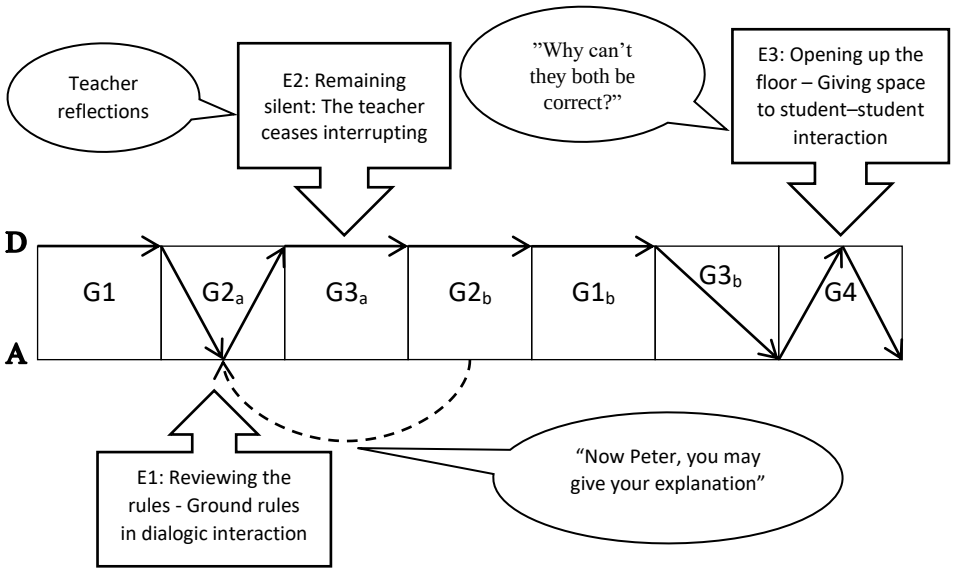

Figure 1. The temporal overview and the transcript examples of the lesson (D = Dialogic and interactive approach and A = Authoritative and interactive approach; Gx = Group x in turn; E = Example episode).

The vertical lines in figure 1 separate the episodes. For example, G1 represents group 1 sharing their ideas with the teacher, the class, or with another group. The arrow in the G1 case shows that dialogic interactions are taking place (i.e., the group is sharing their ideas without interruptions), whereas the up/down or down/up arrows within an episode (i.e., group turns $G2_a$ and G4) present the communicative passages, with the falling arrow in $G3_b$ indicating the change in the overall communicative approach as the teacher starts to close down the preluded dialogic interactions through a more authoritative approach. Instead of pointing out the dichotomy and placing a step from dialogic to authoritative (cf. Lehesvuori et al., 2013), through the falling arrow we revisit and reinforce the idea of a dialectical process that is introduced right at the beginning (Scott et al., 2006).

Before examining the micro-level analysis, the context of the whole-class discussions is described here:

- *Temporal context:* The whole-class discussion takes place at the end of the lesson and the aim is to collect student ideas discussed in groups before more teacher-led conclusions. Some hints for eliciting student ideas and how to use them is provided for the teacher in the lesson task about mirrors and reflection.
- *Instructional context:* The aim of the designed PD program was to develop the teacher’s skills to orchestrate and enhance argumentation in classroom interactions. Within this

framework, *ground rules* for argumentation were provided and developed in collaboration between researchers and teachers (Lehesvuori et al., 2017).

- *Conceptual context:* The topic of the 7th-grade (13-year-old students, on average) physics lesson covers mirrors and reflection. In the lesson task, students are expected to choose and justify an explanation out of four pre-given options. The task includes a picture where three persons, sitting next to each other, are looking at a plane mirror. The main question was: "Who sees who?"

As noted earlier, orchestration can refer to orchestrating classroom activities (Pianta et al., 2012). However, herein, in a way we address this issue as constant and stabilized, as the lesson's structure and activities are set beforehand. Thereby, the focus is targeted on how the teacher orchestrates the process of argumentation through communicative approaches.

The micro-level turn-by-turn analysis of the interactions from the transcript examples is conducted in terms of pointing out interesting features arising from the teacher orchestrating and balancing the dialogic and authoritative approaches. These features include moments where the teacher's prevailing communicative approach is interrupted by indicators of another approach. A dialogic collection of ideas without evaluation is interrupted by the teacher momentarily taking more control of the content and direction of the discussion. This is often indicated by more closed questions or follow-ups by the teacher. Contrastingly, when considering how the teacher's prevailing authoritativeness is challenged through dialogicity, open questions and supportive feedback play a role (Lehesvuori, Ramnarain, & Viiri, 2018).

The analysis conducted in this study originally draws on the general principles of sociocultural discourse analysis, complemented with conversation analysis techniques. Whereas a sociocultural approach to discourse analysis is less focused on the language itself and more on the functions language serves for joint activity analysis (Mercer, 2004), conversational analysis techniques provide ways to access data-emerging patterns (Hsu, Roth, & Mazumder, 2009) or single turns such as teacher feedback (Hall, 2007; Macbeth, 2004; Cullen, 2002) complemented with the consideration of gestures or other multimodal features (Lim, 2019; Kääntä, 2015). A microscopic approach can explicitly demonstrate the prevailing phenomena through the consideration of single turns and gestures (Sert, 2015). In our earlier work, we understood the power that comes from fine-grained analysis and explicitness, but we also complemented the micro-scale interpretations with more holistic approaches to the analysis in order to link

practice with theory and to build on it (Lehesvuori et al., 2013). To open the data-driven features up in enough detail, examples of the transcribed episodes are condensed in length as this is necessary for the interpretations (cf. Lefstein & Snell, 2014). The selection of the examples is based on the consideration of critical moments in temporal surroundings: Myhill (2006) describes these critical moments as opportunities occurring in the classroom in which the teacher either initiates extended dialogues or withdraws and takes authoritative control of the direction of the discussion.

Trustworthiness

The first author carried out the initial observations during the video recording of the case teacher's lesson. Later, the overall whole-class discussion phase was discussed many times from different research angles during the project (e.g., student–student interaction and dialogic moves in argumentation). The preliminary ideas and interpretations of this paper were discussed in project meetings and at scholarly seminars where the first author inquired about the researchers' ideas open-endedly before moving to the joint building of an agreement on the interpretations. Thus, researcher triangulation (Cohen, Manion, & Morrison, 2007) and evaluation have been taken into account. In addition, a partial member check (Lincoln & Guba, 1985) can be considered to have taken place as the case teacher commented on the video clips from his lesson.

Results

The overall temporal overview of the whole-class discussion phase of the lesson shows that the interaction was majorly dialogic (and interactive). Moreover, what has been found (Lehesvuori, Viiri, & Rasku-Puttonen, 2011; Lehesvuori et al., 2013) is that the overall dialogic structure often closes down during the end phase of the teaching sequence (Group 3 second turn = $G3_b$ in the figure 1). Now the focus shifts to the three instances (episodes E1, E2, and E3) that have been highlighted in the lesson overview (figure 1):

1. First, the authoritative passage in Group 2 turn (G2 in figure 1);
2. Second, the critical moment during the dialogic interaction in Group 3 turn (G3 in figure 1);

3. Third, a dialogic passage at the end during Group 4 turn (G4 in figure 1).

Through these examples we will delve into the following issues:

1. Whether and how does the authoritative passage (G2) support the subsequent dialogic interactions?
2. How does the teacher orchestrate and maintain the dialogic interactions (G3)?
3. How does the dialogic passage (G4) build on the closing down phase of the whole-class discussion?

Example 1: Reviewing the rules: Ground rules in dialogic interaction

The following example from a lesson takes place when the teacher gives the turn to the second group (G2). Before the shift, the first group (G1) has shared their ideas. The teacher gives the turn to group 2 without any evaluation or elaboration of group 1's ideas (see G2 in figure 1).

Turn	**Speaker**	**Transcript**	**Descriptions** (critical incidents bolded)
1	Teacher	How about group 2? What do you think about the responses group 1 gave us?	
2	G2/S1	What? What should I say?	
3	Teacher	What do you think about their responses?	
4	G2/S2	I can explain. When the light refracts from the mirror, we see each other…((Teacher interrupts: Hey Peter…))	
5	Teacher	**Hey, Peter! It is not yet time for your response. Because now I'm asking for you to weigh up and comment on the response from group 1. About the response Silvia just made? And, if it doesn't make sense, then you should explain why that doesn't make sense.**	**Authoritative passaging = to set rules for dialogic interaction and argumentation**
6	G2/S1	Well it's because. Well I don't know.	
7	Teacher	Maybe it would be easier if you could see the figure at the same time? ((Places the figure on the projector))	

Gx/Sy, where x stands for a group and y for a student in the group	

The extract and, in particular, Turn 5, is about the teacher bringing the student back to the ground rules of the discussion. That is, instead of giving his idea of the explanation, the group should think about and comment on the explanation of the preluding group. The interruptive teacher's Turn 5 is very strict, controlling the direction of the discussion. Despite the initial purpose of collecting student ideas in the episode, at this moment, the teacher's actions toward student efforts implies *an authoritative passage* is taking place in an otherwise dialogic temporal surrounding. This is illustrated with down–up arrows in the visualization of the whole-class discussions (see G2a in figure 1).

In this example, the thin line between the authoritative and dialogic approaches leads to a question: Do we consider this kind of passage (not directly addressing what is said rather than how and when it is said) as a shift in communicative approach in terms of passage? As brought up in theoretical background, if we think more temporally, we may question whether this authoritative passage actually serves the prevailing and yet-to-be-developed dialogicity. In this example, the decision for the authoritative passage was based on the strict and evaluative, reaction to student efforts, and it may also seem, from the student's point of view (at this point), to be a reaction to what has been said: I.e., from student point of view there was no exploration of student's ideas rather it was neglected (at this point). A clear indicator acknowledged (Scott & Ametller, 2007) is the IRE- triad ending with noted evaluation. Thus, authoritative passage was considered to take place.

In the next example, we will find out that this effort is, however, remembered and revisited by the teacher, thus again bringing in the temporal consideration, and we consider to what extent and whether (or not) to cover it in our analysis and interpretations (cf. Lehesvuori et al., 2013).

Example 2: Remaining silent: The teacher ceases interrupting

In this episode, the teacher orchestrates a whole-class discussion about the argumentation task regarding the reflection from the mirror. The teacher gives turns group by group and expects the groups to challenge each other's ideas. In this excerpt, the teacher has listened to a student group and gives the floor to other groups to comment (see G3 in figure 1).

Turn	Speaker	Transcript	**Descriptions** (critical incidents bolded)
1	Teacher	There, what Hannah just said, is there something to it?	
2	G3/S1	Yeah! [Teacher: Well, let's hear it!] They could have opened up their explanation a bit more. I did not fully understand it.	
3	Teacher	So, they say that everyone sees everyone in the case of that figure? ((Several students interrupt simultaneously: No, it cannot be! It is impossible!))	The teacher opens up the space for students by letting students interrupt and begin the discussion = opening up the dialogic space
4	G1/S1	It doesn't work, when he like looks from that angle.	The teacher remains silent = keeping the dialogic space open
5	G3/S2	Yeah, but does he look straight ahead or toward the mirror?	
6	G2/S1	He cannot see himself if he doesn't look toward the mirror!	
7	G3/S2	The angle of the rays goes in a way that it is not physically possible. ((Several students talk it over))	
8	G3/S1	I think he sees half of himself. **((The teacher raises his finger, yet puts it slowly down and remains silent: see figure 2))**	**The teacher ceases interrupting = maintaining the dialogic space**
9	G3/S2	But I cannot see myself from here. ((Points at a window))	The teacher remains silent = keeping the dialogic space open
10	G1/S1	But he sure sees the others!	
11	G3/S2	Yeah, but he cannot see himself!	
12	G2/S1	Oh, I see! ((The debate continues for few turns after the teacher interrupts))	
13	Teacher	All righty! ((Rising intonation) Then, group 2! Now Peter! You may now give your explanation. ((The teacher acknowledges Peter's previous effort when the teacher was interrupted as it wasn't time then to explain his own responses))	Rising intonation = Dialogic maintenance of the dialogic space

<INSERT FIGURE 2 HERE>

Interpretations: The feature discussed here is the teacher maintaining silence while student groups light up, challenging each other (Turns 3–12). A critical turn that can be seen from the

video takes place when the teacher raises his finger in order to interrupt as student 2 from group 3 proposes his idea: “But I cannot see myself from here.” The teacher finally closes down the episode by announcing “All righty!” (Turn 13) and gives a turn to group 2 to present their explanation. In this turn, the teacher comes back to Peter, who earlier tried to provide his explanation, although the idea was to comment on group 1’s idea. Thus, the turn brings us back to temporality and the tension between the authoritative and dialogic approaches, as earlier, the teacher had refused to listen to Peter’s explanation, yet now opens up the floor for it. In a way, this turn neutralizes the authoritative passage addressed in the first example, thus again strengthening the prevailing dialogic approach.

Teacher reflections: The teacher was introduced to the same episode from the video two weeks after the lesson. There was no specific introduction, and after watching the video, the teacher was asked by researcher 1: “What do you think about the clip?”:

> Teacher: Well, like you sit back and enjoy the ride and observe while students are thinking together. The only thing is that they are 7th-graders, they are kids … like when comparing them to 9th-graders. It might be that I will reuse these tasks with other groups. In a way, to keep control of the speaking turns and the listening would be structured more properly. I mean that it would be nice if they knew that when someone speaks, then it is time to listen. But! There is another side to this when it goes toward authentic and enthusiastic debate. Like when someone has a strong intuition that he is right and the other one is wrong, but how could I justify and explain my idea so that the other would understand it. That kind of discussion could emerge more easily during that kind of debate. I don’t know, maybe it would even be quite boring if the argumentation occasion is overly structured…

The first part of the teacher’s reflection complements the interpretation of the tension between orchestration of the whole-class discussions and giving space to the authentic exchange of ideas (“to keep control…” vs. “There is another side to this when it goes toward authentic and enthusiastic debate”). In other words, at the same time, the teacher struggles with the idea of unstructured debate; he sees the possibility in the free exchange of ideas being like food for a more authentic debate. When it comes to the critical incident pointed out in the analysis, the following reflections emerged:

> Researcher1: I noticed that in one situation you raised your finger, and can you recall what you were thinking there?
>
> Teacher: I think I was pointing out to someone that he/she should be silent?
>
> Researcher1: Oh?

Teacher: Yeah, I think that I tried to indicate someone to be silent, and I thought that it would be better to maintain silence myself.

Researcher1: So, in a way you were keeping the floor open?

Teacher: That's right! Definitely!

Unlike how this was initially and intuitively interpreted, the teacher's idea was not to cease from complementing an idea. It was about controlling one student and, at the same time, remaining silent. Nevertheless, the idea of keeping the floor open to student ideas was brought up by the researcher and then confirmed by the teacher.

As a subsequent notion, it is worthwhile noting Turn 12 ("Oh, I See!") and the "change-of-state" token (Heritage, 1984). This could play a role in making meaning for student realization (meaning-making) as a result of the previous student–student whole-class discussions (cf. Jakonen & Morton, 2015). With this evidence, we can only wonder whether this could be a result of the teacher ceasing to interrupt. Indeed, a different example of teacher orchestration would be the teacher interrupting and reminding students about the basic rules for discussions and listening to each other. However, we may hypothesize that in order to facilitate student-driven meaning-making, the teacher should open up the kind of dialogic spaces within meaningful student–student interactions that can possibly emerge and evolve. This could be a way to move from initial wonderment and challenging ideas to joint student-driven meaning-making.

Example 3: Opening the floor: Giving space to student–student interaction

The next example takes place at the end of whole-class discussions. In the preluding episode ($G3_b$), the prevailing communicative approach shifted to an authoritative one as the teacher was directing the discussion when seeking further justification, especially for option B, via more closed follow-ups and prompt (I.e., despite there still is IRPRP- chains taking place, these are complemented with more authoritative teacher mini-lectures and supplementary IRF-check-ups; Lehesvuori et al., 2013):

Teacher: Well does it conflict with the argument that only B sees every person from the mirror?

G3/S1: Yes!

Teacher: Well how does it conflict then? ((directing follow-up))

G3/S1: Well actually it doesn't.

Teacher: So if B is the only one who sees himself in the mirror, A doesn't and C doesn't, and B we say sees everyone. So in addition to himself, he sees A and C, so are the claims conflicting?

G3/S1&2: No.

G3/S2: Well, in principle, since B is in middle he can see everyone else.

Teacher: And, himself ((complementing student response))

Following the overall discursive pattern (a group commenting on a group) and within the prevailing authoritativeness, the teacher now gives a turn to group 4 to comment on the justifications provided for option B.

Turn	**Speaker**	**Transcript**	**Descriptions** (critical incidents bolded)
1	Teacher	What about group 4? Why would you think option B is a good option?	
2	G4/S1	Firstly, it sounds good ((laugh)). But it is true that person B sees himself, but persons A and C don't see each other. **((Teacher remains silent))**	**Dialogic passaging = the teacher momentarily keeps the floor open for student–student (group-group) interaction**
3	G3/S1	**But can you tell that option D is wrong?**	
4	G4/S1	**Yeah, I can.**	
5	Teacher	But why is option D then wrong(↓)? ((Falling intonation indicates the teacher probing for a further contribution from the respondent))	Probes for further elaboration from the respondent
6	G4/S1	Because we didn't select it.	
7	Teacher	**Why can't they both be correct(↑)? ((A rising intonation here indicates the teacher inviting the class to elaborate))**	**Dialogic passaging = probes for further elaboration from the class (re-opens the floor)**
8	G3/S1&2	Yes, they can ((both S1 and S2). Because it says that you may choose an option … but doesn't say that there is only one correct one.	
9	Teacher	Do the elaborations of group 3 make any sense?	
10	G4/S1	Yeah, they are breathing, and their hearts are pumping, but that's it ((laughs)).	
11	Teacher	What about option C? The persons A and C would see each other, yet they could not see person B? Does it make any sense? (Students: No!) Should we go and try while we go for lunch? ((The lesson ends with the teacher encouraging students to look at the mirrors in the toilets on the way))	

The opening turn by the teacher is a continuation of the preluding authoritative episode: The discussion was narrowed to justify option B. In the prevailing authoritativeness, the dialogic passage takes place when the teacher remains silent and gives the groups the space to challenge each other's ideas (Turns 3–4). Although it is a brief exchange involving group-to-group interaction, the teacher distinctly gives this space that is initially indicated by wait time (i.e., maintaining silent). Triggered by the students' underdeveloped response and time constraints, the teacher momentarily takes control and seeks a further contribution from the student (Turn 5). Yet the student still does not elaborate on his response in any way (Turn 6: "Because we didn't select it"). Thereby, the teacher invites the class to join in (Turn 7). Whereas the falling intonation here could signal more of a closed prompt toward an individual student, the rising intonation in Turn 7 re-opens the floor once more for the whole class to join in the meaning-making process.

Overall, when addressing the issue of opening up the floor once more through the dialogic passage, we see two different examples: In Turn 2, the space for student–student interaction is facilitated through wait time and the teacher maintaining silent; and, in Turn 7, the rising intonation (and a more open "why" question; Chin, 2007) signals to the students that further elaboration is welcomed. Although this may seem more as a confirmatory check-up, in temporal surroundings with prevailing authoritativeness within this episode, a communicational contrast is brought in through dialogicity. Even though this excerpt in isolation could resemble an example of a dialogic episode, the preluding and following authoritative episodes hinder authentic dialogism to develop. A clear marker is the teacher turn (5) interrupting student-student interaction and rushing the focus back to making conclusions.

In this episode, the teacher balances the authoritative (falling intonation) and dialogic (rising intonation) aspects when heading toward the closure of the lesson (cf. Lehesvuori et al., 2013; Lehesvuori, Ramnarain, & Viiri, 2018). Whereas within this episode the falling and rising intonation in the turns resembles the balancing act, more temporally, this resembles a damped oscillation (cf. Lehesvuori et al., 2013) where the space for dialogicity becomes increasingly narrow when proceeding toward the end and final conclusions. In fact, instead leaving conclusion as open "cliffhangers" for students to try by themselves while heading for lunch, teacher leads the conclusions in front of the toilet mirror:

Teacher: The person B is the only one who sees both. And, the other option where B is the only one who sees himself is also correct. You can't see yourself from this angle ((demonstrates with hand: see figure 3))

<INSERT FIGURE 3 HERE>

Drawing on to the previous excerpts and interpretations, it is evident that teacher dialogic turns are dialogic passages within prevailing concluding and authoritative phase merely bringing students voice back to discussion briefly.

Discussion

The findings of this study revealed explicit examples of teacher orchestration. As a part of organizing and setting the ground rules for dialogic discussion, *the first example* presented the teacher interrupting Peter's response authoritatively in the first example extract. However, via a temporal consideration, we demonstrated how the teacher brought Peter back to his initial efforts in terms of idea sharing. Since overall teaching purpose of idea sharing and the dominant dialogicity, authoritativeness can be questioned especially through temporal consideration. Yet, from student point of view, which we highlight, in the situation student idea was not explored and was neglected. Thus, authoritative passage was taking place. Although, in this case serving the continuing dialogic discussions, when frequently implemented, dialogicity is less likely taking place.

The second example was based on noticing the teacher's gesture of raising a finger and maintaining silence during a student explanation and student–student interaction. Through teacher reflections we became aware that the teacher was actually aiming to silence a pupil who was trying to interrupt another student giving an explanation. The teacher acknowledged that his idea was, however, to be silent too in order to keep the space open for student–student interaction. As mirrored in the teacher's reflections, balancing giving space and controlling is challenging and we may want to uncover whether these two aspects are taking place in the same critical moment. We may also want to note that it is this dilemma that is at the heart of teacher orchestration of whole-class discussions constituting both authoritative and dialogic interactions.

The third example resembles our previous findings that when getting closer to the end of the dialogic passages and openings for dialogic discussions, only leads to dialogic moments (Lehesvuori et al., 2013). As we have highlighted during the intervention program (Lehesvuori et al., 2017b) and in previous studies on the importance of the authoritative approach in the closing down phase (Lehesvuori, Viiri, & Rasku-Puttonen, 2011), we often see these dialogic moments echoing the prevailing nature of the preluding discussions. We highlight that we should not see these dialogic moments as a failure to open up dialogic discussion, rather it could have the meaning of softening the edge of authoritativeness and bringing back the students' voice to the concluding phase of the lesson.

Having said this, it may be that these dialogic moments do not fulfil the idea of authentic dialogism as no authentic feeling is given to the students that their ideas are equally considered against the science's/teacher's view (Bakhtin, 1986). Or, there is no true space for authentic dialogicity where different ideas are equally present without evaluation (Wegerif, 2010). This may resemble more of the dialectical process where educational goals and purposefulness are explicitly present and hinder this dialogism. Despite overly stressed purposefulness and cumulativeness (Alexander, 2006) perhaps taking us away from authentic dialogicity, we see these features as an essential part of argumentation (see Lehesvuori et al., 2017) and teacher orchestration of meaningful dialogue. As noted, the dialogic moments could echo the prevailing (yet not overly dominating) communicational orientation of the teacher that in this case could be student-centered and dialogic. These moments could still meaningfully activate and trigger student reasoning, for instance, within more dialogic argumentation (Lehesvuori et al., 2017) or during initial idea sharing within formative assessments (Ruiz-Primo & Furtak, 2007).

Teacher orchestration is often assimilated within the teacher managing the classroom or pursuing, through different activities, control over student actions and behavior. These are also features that can be observed and analyzed in a straightforward manner (cf. Pianta et al., 2012). We introduced, however, a specific and under-researched approach to explore teacher orchestration. Deriving the idea from the findings of this paper, we posit that teacher orchestration also applies different communicative approaches for different purposes during the lesson (cf., framework of Mortimer & Scott, 2003), not only at the episode level, but also within an episode, as the teacher is balancing (and even struggling) with decisions regarding when to passage discussions through the authoritative or dialogic approach. This internal

struggle by the case teacher was evident in his reflections on the second example. In a way, this internally persuasive struggle may represent the internal dialogue of the teacher (Moate, Hulse, Jahnke, & Owens, 2018). Having said this, we argue that to trigger and to nurture this kind of internal dialogue should be at the heart of any intervention, and more widely, of education.

Limitations and implications

We acknowledge that the case study of a single teacher has limitations in terms of generalization. However, we have seen that the in-depth scrutiny of critical moments furthers the concept of teacher orchestration, especially when it comes to teacher orchestration of whole-class discussions. In addition to the micro-scale analysis of single moments, the consideration of temporality complements the interpretations (cf. Lehesvuori et al., 2013). Researcher interpretations were partly weighted by the teacher in reflections, thus giving weight to trustworthiness. As a key implication, we posit that both researchers and teachers should introduce a wide range of the communicational spectrum as a part of the orchestration of whole-class discussions. Furthermore, regarding how communicative approaches and teacher orchestration can be addressed in teacher education, the concrete examples of communicative approaches bring explicitness for conceptualization.

As to the methodological issues, we have presented how specific features of multimodality (Kääntä, 2015) can be applied to point out authoritative and dialogic indicators finally constituting passages or an entity of an episode. As we have previously detected indicators, in particular for dialogicity (Lehesvuori, Ramnarain, & Viiri, 2018), here we have also highlighted indicators related to authoritative passaging. In the first example, it was *a clear verbal intervention* from the teacher that directed the student authoritatively back on track when it came to following the discursive guidelines. Whereas in the second example the teacher's *non-verbal action or a gesture* (Lim, 2019) played a major role in authoritatively maintaining the dialogic space as open for student–student interaction, and in the third example, the *prosody* and consideration of falling and rising intonations (see Lehesvuori, Ramnarain, & Viiri, 2018) played a role when weighing up the authoritativeness and dialogicity of the teacher talk. In summary, instead of addressing multimodal features equally in each example (Kääntä, 2015), one of the multimodal features is given weight in each individual example to stress indicators related to authoritativeness and dialogicity.

Finally, we posit that even though dialogicity is often emphasized, and perhaps should be emphasized, especially in science (e.g., Kumpulainen & Rajala, 2017), the authoritative approach has its place in science classroom interactions (Scott & Ametller, 2007) and should be given equal attention in meaningful learning.

References

Aguiar, O. G., Mortimer, E. F., & Scott, P. (2009). Learning from and responding to students' questions: The authoritative and dialogic tension. *Journal of Research in Science Teaching, 47*(2), 174–193.

Alexander, R. (2006). *Towards dialogic teaching* (3rd ed.) New York, NY: Dialogos.

Alexander, R. (2001). *Culture and pedagogy: International comparisons in primary education*. Oxford: Blackwell.

Bakhtin, M. (1986). *Speech genres and other late essays*. Austin, TX: University of Texas Press.

Bansal, G. (2018). Teacher discursive moves: Conceptualising a schema of dialogic discourse in science classrooms. *International Journal of Science Education*, *40*(15), 1891–1912.

Berland, K. B., & Hammer, D. (2012). Framing for scientific argumentation. *Journal of Research in Science Teaching, 49*(1), 68–94.

Chen, Y., Hand, B., & Norton-Meier, L. (2017). Teacher roles of questioning in early elementary science classrooms: A framework promoting student cognitive complexities in argumentation. *Research in Science Education, 47*(2), 373–405.

Chin, C. (2007). Teacher questioning in science classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching, 44*(6), 815–843.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed.). London: Routledge Falmer.

Cullen, R. (2002). Supportive teacher talk: The importance of the F-move. *ELT Journal, 56*(2), 117–126.

Evans, S., & Dawson, C. (2017). Orchestrating productive whole class discussions: The role of designed student responses. *Mathematics Teacher Education and Development, 19*(2), 159–179.

Finnish National Board of Education. (FNBE). (2016). *Perusopetuksen opetussuunnitelman perusteet 2014* [Finnish core curriculum for basic education 2014]. Helsinki: Valtion Painatuskeskus.

Fleer, M. (2015). Imagination and its contributions to learning in science. In M. Fleer & N. Pramling (Eds.), *A cultural-historical study of children learning science* (pp. 39–57). Netherlands: Springer.

Furtak, E. M., & Shavelson, R. J. (2009). Guidance, conceptual understanding, and student learning: An investigation of inquiry-based teaching in the US. In T. Janik & T. Seidel (Eds.), *The power of video studies in investigating teaching and learning in the classroom* (pp. 181–206). Munich: Waxmann.

Furtak, E. M., Glasser, H., & Wolfe, Z. M. (2016). *The feedback loop: Using formative assessment data for science teaching and learning.* Arlington, VA: National Science Teachers Association Press.

Heritage, J. (1984). A change-of-state token and aspects of its sequential placement. In J. M. Atkinson & J. Heritage (Eds.), *Structures of social action: Studies in conversation analysis* (pp. 299–345). Cambridge: Cambridge University Press.

Hall, J. K. (2007). Redressing the roles of correction and repair in research on second and foreign language learning. *The Modern Language Journal, 91*, 511–526.

Hsu, P.-L., Roth, W.-M., & Mazumder, A. (2009). Natural pedagogical conversations in high school students' internship. *Journal of Research in Science Teaching, 46*(5), 481–505.

Hämäläinen, R., Kiili, C., & Smith, B. E. (2017). Orchestrating 21st century learning in higher education: A perspective on student voice. *British Educational Technology, 48*(3), 1106–1118.

Jakonen, T., & Morton, T. (2015). Epistemic search sequences in peer interaction in a content-based language classroom. *Applied Linguistics, 36*(1), 73–94.

Kiemer, K., Gröschner, A., Pehmer, A.-K., & Seidel, T. (2015). Effects of a classroom discourse intervention on teachers' practice and students' motivation to learn mathematics and science. *Learning and Instruction, 35*, 94–103.

Kumpulainen, K., & Rajala, A. (2017). Dialogic teaching and students' discursive identity negotiation in the learning of science. *Learning and Instruction, 48*, 23–31.

Kvale, S. (1996). *InterViews: An introduction to qualitative research interviewing*. Thousand Oaks, CA: Sage.

Kääntä, L. (2015). The multimodal organization of teacher-led classroom interaction. In C. Jenks & P. Seedhouse (Eds.), *International perspectives on ELT classroom interaction* (pp. 64–83). Hampshire: Palgrave Macmillan.

Lefstein, A., & Snell, J. (2014). *Better than best practice: Developing teaching and learning through dialogue*. London: Routledge.

Lehesvuori, S., Ratinen, I., Kulhomäki, O., Lappi, J., & Viiri, J. (2011). Enriching primary student teachers' conceptions about science teaching: Towards dialogic inquiry-based teaching. *Nordic Studies in Science Education, 7*(2), 140-159.

Lehesvuori, S., Viiri, J., & Rasku-Puttonen, H. (2011). Introducing Dialogic Teaching to Science Student Teachers. *Journal of Science Teacher Education, 22*(8), 705-727.

Lehesvuori, S., Viiri, J., Rasku-Puttonen, H., Moate, J., & Helaakoski, J. (2013). Visualizing communication structures in science classrooms: Tracing cumulativity in teacher-led whole class discussions. *Journal of research in science teaching, 50*(8), 912-939.

Lehesvuori, S., Hähkiöniemi, M., Jokiranta, K., Nieminen, P., Hiltunen, J., & Viiri, J. (2017). Enhancing Dialogic Argumentation in Mathematics and Science. *Studia Paedagogica, 22*(4), 55-76.

Lehesvuori, S., Chan, K. K. H., Ramnarain, U., & Viiri, J. (2017). In Search of Dialogicity : A Comparison of Curricular Documents and Classroom Interactions from Finland and Hong Kong. *Education Sciences, 7*(4), 76.

Lehesvuori, S., Ramnarain, U., & Viiri, J. (2018). Challenging Transmission Modes of Teaching in Science Classrooms : Enhancing Learner-Centredness through Dialogicity. *Research in Science Education, 48*(5), 1049-1069.

Lemke, J. L. (1990). Talking science: Language, learning and values. Norwood: Ablex Publishing Company.

Lim, F. V. (2019). Analysing the teachers' use of gestures in the classroom: A systemic functional multimodal discourse analysis approach. *Social Semiotics, 29*(1), 83–111.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage.

Littleton, K., & Howe, C. (Eds.). (2009). *Educational dialogues: Understanding and promoting productive interaction*. London: Routledge.

Littleton, K., & Kerawalla, L. (2012). Trajectories of inquiry learning. In K. Littleton, E. Scanlon, & M. Sharples (Eds.), *Orchestrating inquiry Learning* (pp. 31–47). Oxford: Routledge.

Ludvigsen, S., Rasmussen, I., Ingeborg, K., Moen, A., & Middleton, D. (2010). Intersecting trajectories of participation: Temporality and learning. In S. Ludvigsen, A. Lund, I.

Rasmussen, & R. Säljö (Eds.), *Learning across sites: New tools, infrastructures and practices* (pp. 105–121). London: Routledge.

Macbeth, D. (2004). The relevance of repair for classroom correction. *Language in Society, 30*, 703–736.

Mehan, H. (1979). Learning lessons: Social organization in the classroom. Cambridge, MA: Harvard University Press.

Mercer, N. (2000). Words and minds: How we use language to think together. London: Routledge.

Mercer, N. (2004). Sociocultural discourse analysis: Analysing classroom talk as a social mode of thinking. *Journal of Applied Linguistics, 1*(2), 137–168.

Mercer, N., Dawes, L., & Staarman, K. (2009). Dialogic teaching in the primary science classroom. Language and Education, 23(4), 353-369.

Mercer, N., Hennessy, S., & Warwick, P. (2017). Dialogue, thinking together and digital technology in the classroom: Some educational implications of a continuing line of inquiry. *International Journal of Educational Research*. https://doi.org/10.1016/j.ijer.2017.08.007

Mercer, N., Hennessy, S., & Warwick, P. (2010). Using interactive whiteboards to orchestrate classroom dialogue. *Technology, Pedagogy and Education, 19*(2), 195–209.

Moate, J., Hulse, B., Jahnke, H., & Owens, A. (2018). Exploring the material mediation of dialogic space: A qualitative analysis of professional learning in initial teacher education based on reflective sketchbooks. *Thinking Skills and Creativity*. https://doi.org/10.1016/j.tsc.2018.12.003

Mortimer, E. F., & Scott, P. (2003). *Meaning making in science classrooms*. Milton Keynes: Open University Press.

Muhonen, H., Pakarinen, E., Poikkeus, A.-M., Lerkkanen, M.-K., & Rasku-Puttonen, H. (2018). Quality of educational dialogue and association with students' academic performance. *Learning and Instruction, 55*, 67–79.

Myhill, D. (2006). Talk, talk, talk: Teaching and learning in whole class discourse. *Research Papers in Education, 21*(1), 19–41.

Nurkka, N., Viiri, J., Littleton, K. S., & Lehesvuori, S. (2014). A methodological approach to exploring the rhythm of classroom discourse in a cumulative frame in science teaching. *Learning, Culture and Social Interaction, 3*(1), 54-63.

O'Connor, C., Michaels, S., Chapin, S., & Harbaugh, A. (2017). The silent and the vocal: Participation and learning in whole-class discussion. *Learning and Instruction, 48*, 5–13.

Pianta, R. C., Hamre, B. K., & Mintz, S. L. (2010). *Classroom assessment scoring system: Secondary (CLASS-S)*. Charlottesville, VA: University of Virginia.

Reveles, J., Kelly, G., & Durán, R. P. (2007). A sociocultural perspective on mediated activity in third grade science. *Cultural Studies of Science Education, 1*(3), 467–495.

Ruiz-Primo, M. A., & Furtak, E. M. (2007). Exploring teachers' informal formative assessment practices and students' understanding in the context of scientific inquiry. *Journal of Research in Science Teaching, 44*(1), 57–84.

Scott, P. & Ametller, J. (2007). Teaching science in a meaningful way: Striking a balance between 'opening up' and 'closing down' classroom talk. *School Science Review, 88*(324), 77-83.

Scott, P. H., Mortimer, E. F. & Aguiar, O. G. 2006. The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons. Science Education, 90(4), 605-631.

Scott, P., & Ametller, J. (2007). Teaching science in a meaningful way: Striking a balance between “opening up” and “closing down” classroom talk. *School Science Review, 88*(324), 77–83.

Sedova, K., Sedlacek, M., & Svaricek, R. (2016). Teacher professional development as a means of transforming student classroom talk. *Teaching and Teacher Education, 57*, 14–25.

Sert, O. (2015). *Social interaction and L2 classroom discourse*. Edinburgh: Edinburgh University Press.

Sinclair, J., & Coulthard, M. (1975). *Towards an analysis of discourse*. London: Oxford University Press.

Teo, P. (2016). Exploring the dialogic space in teaching: A study of teacher talk in the pre-university classroom in Singapore. *Teaching and Teacher Education, 56*, 47–60.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Webb, N. 2009. The teacher’s role in promoting collaborative dialogue in the classroom. British Journal of Educational Psychology, 79(1), 1-28.

Wegerif, R. B. (2010). Dialogue and teaching thinking with technology: Opening, expanding and deepening the “inter-face.” In K. Littleton & C. Howe (Eds.), *Educational dialogues: Understanding and promoting productive interaction* (pp. 338–357). London: Routledge.

Westerman, D. A. (1991). Expert and novice teacher decision making. *Journal of Teacher Education, 42*(4), 292–305.

Yin, R. (1994). *Case study research: Design and methods* (2nd ed.). Beverly Hills, CA: Sage.

Zaccarelli, F. G., Schindler, A-K., Borko, H., & Osborne, J. (2018). Learning from professional development: A case study of the challenges of enacting productive science discourse in the classroom. *Professional Development in Education, 44*(5), 721–737.